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EVALUATION OF PROPOSED NPDES PERMIT LIMITATIONS FOR HOMESTAKE MINING COMPANY AND LEAD-DEADWOOD SANITARY DISTRICT NUMBER 1

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INTRODUCTION

In September 1971 NFIC-D and Regions VII and VIII prepared the document "Pollution Affecting Water Quality of the Cheyenne River System in Western South Dakota." The document, including its conclusions and recommendations, became the U. S. Government presentation at an Enforcement Conference held in Rapid City, S. Dak., October 19-22, 1971. A major portion of the document specifically addressed pollution from the Homestake Mining Company waste discharges. Recommendations of the EPA document and the Conferees (state and federal pollution abatement officials) included the construction and operation by the Homestake Mining Company of treatment facilities to reduce cyanide, mercury, arsenic and tailings solids pollution.

Since the 1971 Conference, the Homestake Mining Company has proposed several treatment alternatives, including the discharging of liquid wastes into a proposed Lead-Deadwood Wastewater treatment facility. The CH_2M-Hill Consulting Company of Seattle, Wash. is presently studying the problem and designing treatment facilities for the Lead-Deadwood Sanitary District No. 1.

On November 14, 1974, the EPA held a public hearing in South Dakota, in accordance with Section 101 (e) of PL 92-500. Information exchanged at the hearing will be considered before issuance of the NPDES permits to the Homestake Mining Company and the Lead-Deadwood Sanitary District No. 1. At the hearing, the EPA proposed effluent limitations to which the Homestake Mining Company objected. The industry objected to some of

the limitations they felt were too stringent. As part of the Hearing Record, it was agreed that the EPA would determine effluent limitations and monitoring requirements based on the review of industry information presented to the Agency within 20 days (by Dec. 4, 1974) and, if necessary, based on a limited field or laboratory study of the industry wastes and receiving water.

On November 21, 1974, the EPA Regional Administrator requested (see Appendix) that the NFIC-D conduct the studies necessary to accomplish the following objectives:

1. Determine the toxicity of the 1977 effluent conditions as proposed in the NPDES permits to Homestake Mining Company and Lead-Deadwood Sanitary District No. 1.
2. Determine the suitability of background and receiving waters of Whitewood Creek and diverted Spearfish Creek for support of a coldwater fishery.

As a result of this request, NFIC-D performed the necessary investigations from January 8-24, 1975. This report describes the studies conducted, presents findings and conclusions, and provides recommendations relative to the NPDES permit limitations.

CONCLUSIONS

1. The bioassays of the simulated waste of the Homestake Mining Company and the Lead-Deadwood Sanitary District No. 1 demonstrated that both effluents are potentially toxic to the degree that test fish were killed in 96 hours or less (acute toxicity). The results of these bioassays indicated that the proposed 1977 permit limitations for cyanide are not adequate. Acute toxicity occurred with cyanide concentrations of approximately 0.07 mg/l, three times greater than the proposed permit limitations. The proposed limitations cannot be expected to assure the survival and reproduction necessary to maintain a permanent coldwater fishery. Chronic exposure to cyanide concentrations of 0.2 mg/l has been shown to produce abnormal behavior in coldwater fishes.

2. The combined Homestake Mining Company and Lead-Deadwood Sanitary District No. 1 waste was considerably more toxic than the Homestake Mining Company simulated waste alone. The increased toxicity of this waste was attributed to the complexing of cyanide and chlorine to form highly toxic cyanogen chloride.

3. Both the "slime plant" and the "sand plant" effluents were acutely toxic at approximately the same cyanide concentrations as the simulated wastes. An effective concentration that killed 50 percent of the test fish (EC50) in the "slime plant" discharge test was determined to be a 0.07 percent concentration of effluent containing 0.07 mg/l total cyanide. No EC50 was estimated for the "sand plant" discharge; however acute toxicity was observed at a 0.8 percent effluent concentration.

4. Analyses of bioassay results and supporting chemical data led to the conclusion that cyanide was the principal toxic agent. In all tests, fish kills were associated with total cyanide concentrations from 0.07 to 0.11 mg/l.

5. There was no indication that either heavy metals or un-ionized ammonia, at the levels specified in the 1977 permit, contributed to the toxicity of the waters tested. In fact, copper and iron limitations in the proposed 1977 permit are lower than the concentrations of these metals detected in Whitewood Creek, upstream from Gold Run, which supports a permanent coldwater fishery.

6. In situ exposure of rainbow trout demonstrated that the quality of Whitewood Creek upstream from the Gold Run confluence, its tributaries (Strawberry Creek and Grizzly Creek) and diverted Spearfish Creek were sufficient to support a coldwater fishery. Whitewood Creek downstream from the Gold Run discharge was extremely toxic to rainbow trout; all test fish died in less than 15 minutes of exposure. However, if the concentrations of pollutants discharged to Whitewood Creek at Gold Run were reduced to acceptable levels, Whitewood Creek downstream from this point could support a coldwater fishery.

RECOMMENDATIONS

To improve the water quality of Whitewood Creek sufficiently to establish a coldwater fishery and assure the protection of aquatic biota, the following recommendations are made for the Homestake Mining Company and the Lead-Deadwood Sanitary District No. 1 discharges:

1. Total cyanide concentrations shall not exceed 0.005 mg/l (1/20 EC50). In the absence of analytical procedures having detection limits in this range, total cyanide concentrations shall be limited to the presently detectable limit of 0.02 mg/l.

2. To prevent the formation of cyanogen chloride, effluents containing cyanide shall not be combined with wastewaters containing residual chlorine.

3. Heavy metal concentrations as proposed in permits No. SD0000043 and No. SD0020796 shall be implemented in the final NPDES permits.

4. Total ammonia and residual chlorine levels shall be adopted in the final NPDES permits as stated in the proposed limitations, providing recommendations 1 through 3 of this document have been met.

RESULTS AND DISCUSSION

BIOASSAY TESTS

Continuous flow bioassays were conducted during the survey to determine if the proposed effluent limitations are adequate to protect the aquatic life of the receiving waters. Two bioassays employed simulated wastes representing the Homestake Mining Company and the combined effluents of the Homestake Mining Company plus the Lead-Deadwood Sanitary District No. 1. The chemical components and concentrations used were based on the 1977 effluent limitations in NPDES permits SD0000043 and SD0020796 prepared by EPA Region VIII (Table 1). Two components, iron and copper, were found to exist in the receiving water (Whitewood Creek upstream from the Gold Run Creek confluence) at concentrations greater than those of the permit limitations (Table 2).

To assure that the simulated wastes actually represented the chemical characteristics of the Homestake Mining Company effluent, two additional bioassays were conducted using plant discharges diluted with process water to chemical concentrations similar to those of the simulated wastes.

The Homestake Mining Company simulated waste was shown to be acutely toxic. It killed test fish within 96 hours at concentrations of cyanide and heavy metals four times that of the permit limitations (Table 2). At this level (0.09 mg/l-CN), within the first 24 hours of exposure, some test fish displayed signs of sublethal toxification (i.e., general loss of equilibrium and erratic swimming patterns). Within 72 hours, ten percent mortality had occurred among the fish (Table 2). No additional mortalities were observed during the 96-hour test. Insufficient mortalities

Table 1
Effluent Limitations in NPDES Permits
July 1, 1977

Effluent Characteristic	Homestake No. SD-0000043 (mg/l)	Homestake Plus Municipal No. SD-0020796 (mg/l)
Ammonia (as N)		0.6
Total Residual Chlorine		0.02
Total Iron	0.2	0.3
Free Cyanide	0.005	0.008
Total Cyanide	0.02	0.03
Total Arsenic	0.1	0.16
Total Cadmium	0.003	0.005
Total Chromium	0.05	0.08
Total Copper	0.02	0.03
Total Lead	0.05	0.08
Dissolved Lead	0.015	0.022
Total Mercury	0.0002	0.0003
Total Nickel	0.2	0.31
Total Silver	0.0002	0.0003
Total Zinc	0.04	0.06

Table 2

Bioassay Data[a/]
Homestake Mining Company, Simulated Effluent
Lead, South Dakota - January 11-15, 1975

Parameter	4x[b/]	3x	2x	x	0.5x	0.25x	Control (Receiving water)
pH (Units)	7.9	7.9	7.8	7.85	7.8	7.8	7.7
DO	7.1	6.65	7.25	7.35	7.45	7.5	7.25
Temperature (°C)	12.6		12.6				13.1
Specific Conductance (µmho/cm)	495		522				522
Total Alkalinity	252		196				149
Total Hardness	253		198				155
Total Iron	0.24 (0.8)	0.18 (0.6)	0.12 (0.4)	0.06 (0.2)	0.03 (0.1)	0.015 (0.05)	3.1
Total Cyanide	0.10 (0.08)	0.075 (0.06)	0.05 (0.04)	0.025 (0.02)	0.012 (0.01)	0.006 (0.005)	<0.02
Total Arsenic	0.36 (0.4)	0.27 (0.3)	0.18 (0.2)	0.09 (0.1)	0.045 (0.05)	0.022 (0.025)	<0.100
Total Cadmium	0.005 (0.012)	0.004 (0.009)	0.0025 (0.006)	0.001 (0.003)	0.0005 (0.0015)	0.0002 (0.0007)	<0.002
Total Chromium	0.04 (0.20)	0.03 (0.15)	0.02 (0.10)	0.01 (0.05)	0.005 (0.025)	0.0025 (0.0125)	<0.01
Total Copper	0.079 (0.08)	0.059 (0.06)	0.040 (0.04)	0.020 (0.02)	0.010 (0.01)	0.005 (0.005)	0.044
Total Lead	<0.02 (0.20)	<0.02 (0.15)	<0.02 (0.10)	<0.02 (0.05)	<0.02 (0.025)	<0.02 (0.0125)	<0.02
Dissolved Lead	<0.02 (0.06)	<0.02 (0.045)	<0.02 (0.030)	<0.02 (0.015)	<0.02 (0.0075)	<0.02 (0.0038)	<0.02
Total Mercury	0.0002 (0.0008)	0.0002 (0.0006)	0.0001 (0.0004)	0.00005 (0.0002)	0.000025 (0.0001)	0.000012 (0.00005)	0.0003
Total Nickel	0.86 (0.8)	0.64 (0.6)	0.43 (0.4)	0.22 (0.2)	0.11 (0.1)	0.05 (0.05)	<0.01
Total Silver	<0.004 (0.0008)	<0.004 (0.0006)	<0.004 (0.0004)	<0.004 (0.0002)	<0.004 (0.0001)	<0.004 (0.00005)	<0.004
Total Zinc	0.084 (0.16)	0.063 (0.12)	0.042 (0.08)	0.021 (0.04)	0.011 (0.02)	0.005 (0.01)	0.036
% Survival							
at 24 hours	100	100	100	100	100	100	100
at 48 hours	100	100	100	100	100	100	100
at 72 hours	90	100	100	100	100	100	100
at 96 hours	90	100	100	100	100	100	100

a/ Avg. values in mg/l. Data as analyzed; concentrations in parentheses based on permit limitations.
b/ X represents proposed 1977 effluent limitations.

precluded an estimation of a 96-hour EC50[1/] for this simulated waste.

The combined Homestake Mining Company and the District No. 1 simulated waste was more toxic than the Homestake Mining Company simulated waste alone. All test fish died in the undiluted simulated waste (four times limitation) during the first 48 hours of exposure. Forty percent mortality occurred at the 75 percent level (three times effluent permit limitations) within 96 hours (Table 3). A 96-hour EC50 for the undiluted simulated waste was estimated to be a 78 percent concentration, representing a level about three times the permit limitations.

Supporting chemical data showed the Homestake Mining Company simulated waste and the combined Homestake and District No. 1 simulated wastes contained cyanide concentrations of 0.10 mg/l (Table 3). It has been demonstrated that free cyanide (Cn + HCN) becomes acutely toxic to trout in the range of 0.05-0.10 mg/l (1,2). The combined simulated wastes differed in composition from the Homestake Mining Company simulated waste only by the addition of chlorine and ammonia at levels of 0.08 mg/l and 2.4 mg/l (total ammonia-N), respectively. At the test temperature and pH (12°C and 7.7), insufficient un-ionized ammonia was available to be acutely toxic to fish (3). Therefore, it is probable that the increase in toxicity of the combined waste was primarily the result of chlorine addition. Field testing failed to establish the presence of any free chlorine in the combined simulate, precluding the possibility that chlorine was the toxic agent. However, chlorine complexes readily form with cyanide to produce cyanogen chloride, which has

1/ "96-hour EC50" is an abbreviation referring to the effective concentration of contaminant required to kill the 50th percentile in a group of test animals during a 96-hour exposure. The 50th percentile is selected in toxicity tests because it represents the average animal.

Table 3

Bioassay Data[a/]
Homestake Mining Company Plus Municipal, Simulated Effluent
Lead, South Dakota - January 11-15, 1975

Parameter	4x[b/]	3x	2x	x	0.5x	0.25x	Control (Receiving water)
pH (Units)	7.8	7.8	7.7	7.8	7.7	7.7	7.6
DO	8.2	7.6	7.6	7.9	8.0	7.8	7.3
Temperature (°C)	11.0	13.5	12.0	11.0	11.0	11.0	12.5
Specific Conductance (umho/cm)	517		505				519
Total Alkalinity	246		196				148
Total Hardness	247		198				155
Ammonia (as N)	<0.1 (2.4)	<0.1 (1.8)	<0.1 (1.2)	<0.1 (0.6)	<0.1 (0.3)	<0.1 (0.2)	<0.1
Total Residual Chlorine	<0.01 (0.08)	<0.01 (0.06)	<0.01 (0.04)	<0.01 (0.02)	<0.01 (0.01)	<0.01 (0.005)	<0.01
Total Iron	<0.1 (1.2)	<0.08 (0.9)	<0.05 (0.6)	<0.02 (0.3)	<0.01 (0.2)	<0.005 (0.1)	3.1
Total Cyanide	0.1 (0.12)	0.08 (0.09)	0.05 (0.06)	0.02 (0.03)	0.01 (0.02)	0.005 (0.01)	<0.02
Total Arsenic	0.39 (0.64)	0.30 (0.48)	0.20 (0.32)	0.10 (0.16)	0.05 (0.08)	0.02 (0.04)	<0.1
Total Cadmium	0.007 (0.02)	0.005 (0.02)	0.004 (0.01)	0.002 (0.005)	0.001 (0.002)	0.0005 (0.001)	<0.002
Total Chromium	<0.02 (0.32)	<0.02 (0.24)	<0.01 (0.16)	<0.005 (0.08)	<0.002 (0.04)	<0.001 (0.02)	<0.01
Total Copper	0.087 (0.12)	0.065 (0.09)	0.044 (0.06)	0.022 (0.03)	0.011 (0.02)	0.006 (0.01)	0.044
Total Lead	<0.02 (0.32)	<0.02 (0.24)	<0.02 (0.16)	<0.02 (0.08)	<0.02 (0.04)	<0.02 (0.02)	<0.02
Dissolved Lead	<0.02 (0.088)	<0.02 (0.066)	<0.02 (0.044)	<0.02 (0.022)	<0.02 (0.011)	<0.02 (0.006)	<0.02
Total Mercury	0.0003 (0.0012)	0.0002 (0.0009)	0.0002 (0.0006)	0.0001 (0.0003)	0.00005 (0.0002)	0.00002 (0.0001)	0.0003
Total Nickel	1.0 (1.2)	0.8 (0.9)	0.5 (0.62)	0.2 (0.31)	0.1 (0.2)	0.05 (0.1)	<0.01
Total Silver	<0.004 (0.0012)	<0.004 (0.0009)	<0.004 (0.0006)	<0.004 (0.0003)	<0.004 (0.0002)	<0.004 (0.0001)	<0.004
Total Zinc	0.076 (0.24)	0.057 (0.18)	0.038 (0.12)	0.019 (0.06)	0.010 (0.03)	0.005 (0.02)	0.036
% Survival							
at 24 hours	90	100	100	100	100	100	100
at 48 hours	0	80	100	100	100	100	100
at 72 hours		60	100	100	100	100	100
at 96 hours		60	100	100	100	100	100

a/ Avg. values in mg/l. Data as analyzed; concentrations in parentheses based on permit limitations.
b/ X represents proposed 1977 limitations.

been demonstrated to be more toxic to rainbow trout than cyanide alone (4). Qualitative testing was positive for the presence of cyanogen chloride; thus, it appears that the increased toxicity of the combined simulated waste was due to the formation of this compound. Heavy metals were not found in concentrations which were acutely toxic to fish (Table 3).

While no mortalities occurred in either simulated waste at the proposed limitation level, it does not appear that these limitations are adequate, particularly in regard to cyanide and chlorine concentrations. The bioassays indicated that both simulated wastes are acutely toxic at levels three to four times the permit limitations. This is a small margin in light of the fact that safe levels for long-term survival and reproduction of fish are calculated using application factors of 1/20 to 1/100 of the acutely toxic level (EC50). Little study has been made of the chronic effects of cyanide on coldwater fishes; however, there is evidence that chronic exposure to cyanide levels of less than .02 mg/l produces abnormal behavior (1).

The bioassays of the actual Homestake Mining Company effluents were accomplished using wastewater collected at 1) the "slime plant" sluice inside the plant proper, and 2) the "sand plant" sluice at the head of the sand dam. Water was collected daily in sufficient quantities to operate the diluter system. Both effluents were settled for approximately two hours and the supernatant was siphoned. All bioassays were conducted using presettled, filtered supernatant.

The "slime plant" effluent was extremely toxic, and 100 percent mortality was observed at concentrations as low as 0.1 percent (0.10 mg/l cyanide) during the 96-hour test (Table 4). An EC50 for this discharge was estimated to be a 0.070 percent concentration of the

Table 4

Bioassay Data[a/]
Homestake Mining Company "Slime Plant" Effluent
Lead, South Dakota - January 17-21, 1975

Parameter	Effluent Concentrations 0.2%	0.15%	0.1%	0.05%	0.025%	0.0125%	Control (Receiving Water)
pH (units)	7.8	7.9	7.8	7.8	7.8	7.8	7.8
Dissolved Oxygen	8.9	9.0	9.0	8.8	8.6	8.6	8.4
Temperature (°C)	12.0	12.0	12.0	12.0	12.0	12.0	12.2
Specific Conductance (mho/cm)	496	461	520	530	540	545	554
Total Alkalinity	251		194				138
Total Hardness	251		197				146
Total Iron	0.12	0.09	0.06	0.03	0.02	0.01	3.1
Total Cyanide	0.21	0.16	0.10	0.05	0.02	0.01	<0.02
Total Arsenic	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Cadmium	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Total Chromium	<0.01	<0.008	<0.005	<0.002	<0.001	<0.0005	<0.01
Total Copper	0.016	0.012	0.008	0.004	0.002	0.001	0.044
Total Lead	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Dissolved Lead	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total Mercury	<0.0002	<0.0002	<0.0001	<0.00005	<0.00002	<0.00001	<0.0003
Total Nickel	<0.01	<0.008	<0.005	<0.002	<0.001	<0.0005	<0.01
Total Silver	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Total Zinc	0.008	0.006	0.004	0.002	0.001	0.0005	0.036
Survival							
at 24 hours	0	0	100	100	100	100	100
48 hours			0	100	100	100	100
72 hours				100	100	100	100
96 hours				100	100	100	100

a/ Avg. values in mg/l.

effluent. Supporting chemical data (Table 4) showed this level to contain a consistent cyanide concentration of 0.07 mg/l which is acutely toxic to trout. No other single component was found in sufficient quantity to be acutely toxic.

The "sand plant" discharge was not as toxic as the "slime plant" effluent. Mortalities were observed only at the 0.8 percent level and occurred within the first 48 hours of the test. At this concentration, 100 percent of the test fish died (Table 5). Chemical data indicated that the cyanide concentration in this discharge was variable (0.04 to 0.11 mg/l CN). The initial cyanide concentration of 0.11 mg/l (at the 0.8 percent level) declined sharply after the first 24 hours. This accounts for the initial mortality observed in the highest concentration with no subsequent death occurring in the bioassay. Consequently, it was not practical to estimate an EC50 value for this effluent on the basis of these studies.

In general, the four bioassays indicated cyanide or a cyanide complex (cyanogen chloride) was the principal toxic agent. In all cases, fish mortality was associated with total cyanide levels ranging from 0.07 to 0.11 mg/l. Although heavy metals were common to all waters tested and chlorine was a known addition to the combined simulated waste, the possibility of either being the prime toxic agent has been rejected for the following reasons:

1. Heavy metals were not detected at levels generally known to be acutely toxic to fish (Tables 2 to 5) (5)(6). Hard water (greater than 120 mg/l-$CaCO_3$) decreases the toxicity of most heavy metals (Fig. 1)(7)(8). The acute (48-hour) toxicity of copper, for instance, decreases approximately 350 percent with a

Table 5

Bioassay Data[a/]
Homestake Mining Company "Sand Plant" Effluent
Lead, South Dakota - January 17-21, 1975

Parameter	Effluent Concentrations						Control (Receiving Water)
	0.8%	0.6%	0.4%	0.2%	0.1%	0.05%	
pH (Units)	7.8	7.8	7.8	7.8	7.8	7.8	7.7
Dissolved Oxygen	8.8	8.8	8.8	8.8	8.8	8.7	8.6
Temperature (°C)	11.0	11.2	11.4	11.0	11.3	11.2	12.2
Specific Conductance (µmho/cm)	489	510	508	515	535	530	552
Total Alkalinity	250		198				143
Total Hardness	256		200				151
Total Iron	<0.10	<0.08	<0.05	<0.02	<0.01	<0.005	3.1
Total Cyanide	0.07	0.05	0.04	0.02	0.01	0.005	<0.02
Total Arsenic	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Cadmium	<0.002	<0.002	<0.001	<0.0005	<0.0002	<0.0001	<0.002
Total Chromium	<0.01	<0.008	<0.005	<0.002	<0.001	<0.0005	<0.01
Total Copper	0.018	0.014	0.009	0.004	0.002	0.001	0.044
Total Lead	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Dissolved Lead	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total Mercury	<0.0005	<0.0004	<0.0002	<0.0001	<0.00005	<0.00002	0.0003
Total Nickel	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Silver	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Total Zinc	0.025	0.019	0.012	0.006	0.003	0.002	0.036
% Survival							
at 24 hours	100	100	100	100	100	100	100
at 48 hours	0	100	100	100	100	100	100
at 72 hours		100	100	100	100	100	100
at 96 hours		100	100	100	100	100	100

a/ Avg. values in mg/l.

corresponding increase in water hardness from 50 to 200 mg/l. The total hardness of all test waters (ranging from 146 to 256 mg/l) was in excess of 120 mg/l-$CaCO_3$ (Fig. 1).

2. Field testing did not reveal the presence of free chlorine in the combined simulated waste.

3. The physical appearance and behavioral characteristics of stricken fish were indicative of cyanide poisoning. Early signs of stress were exhibited by erratic whirling swimming, followed by a gradual loss of equilibrium. Death was preceded by violent convulsions ending in extreme longitudinal torsion of the body (approaching 90°). Gills of dead fish were widely flared and dark pink in color. These are not symptoms associated with either heavy metal or chlorine poisoning in fish but are commonly associated with cyanide poisoning.

FISH SURVIVAL STUDIES

To determine the suitability of background and receiving waters of Whitewood Creek and diverted Spearfish Creek for support of a coldwater fishery, young-of-the-year rainbow trout were exposed in situ at six sites (Table 6).

All fish survived the five-day exposure at five sites and showed no signs of stress or abnormalities during the five-day exposure and observation period. At Whitewood Creek downstream from Gold Run, all the fish underwent immediate stress when placed in the stream and died within 15 minutes after exposure.

These exposure tests indicated that the quality of Whitewood Creek and its principal tributaries in all reaches upstream of Gold Run was satisfactory to support a coldwater fishery. Field studies (9) have demonstrated that coldwater fishes (Brook trout and Longnose dace) survive and reproduce in stretches of Whitewood Creek 50 to 100 yards

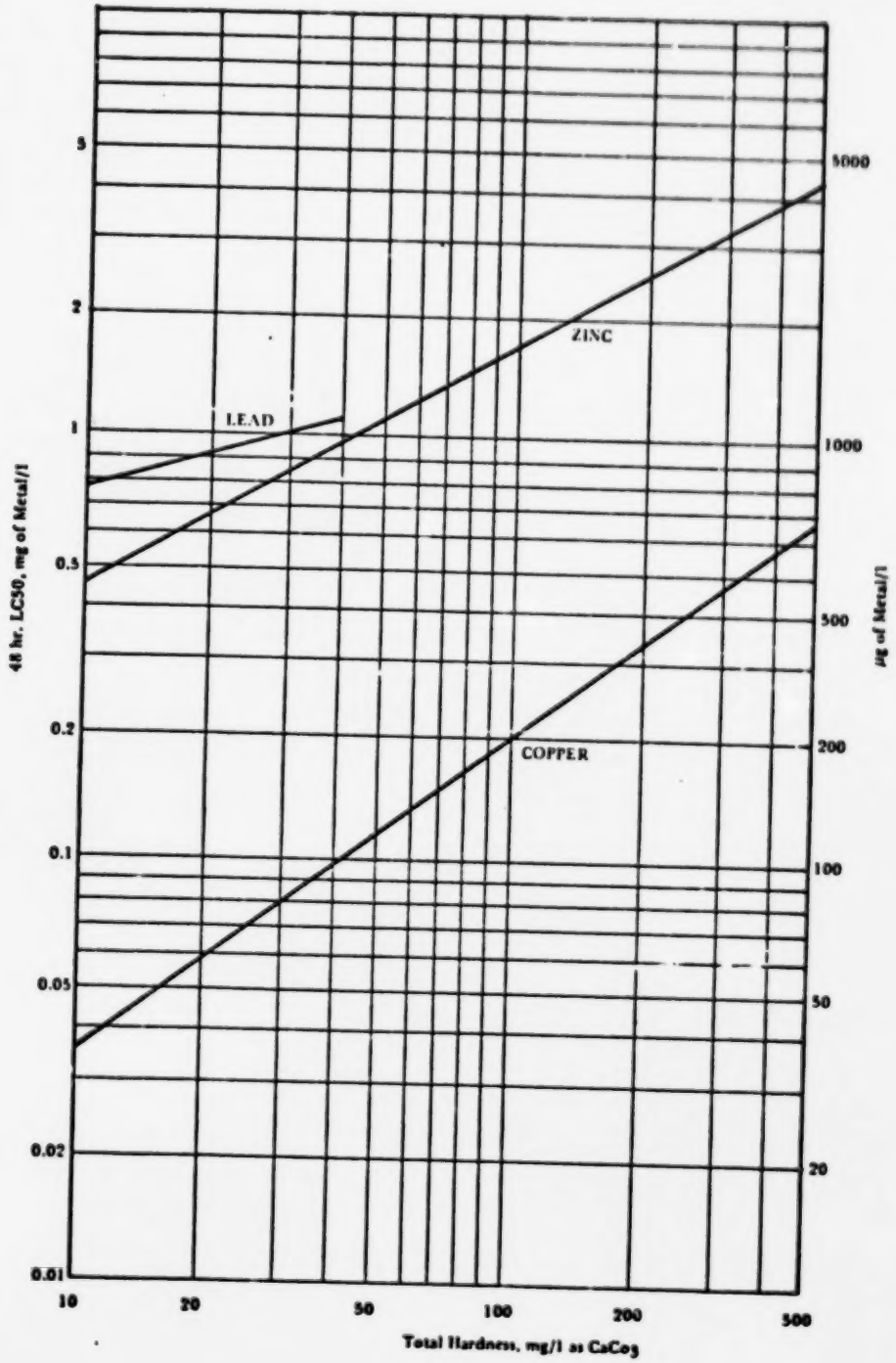

Figure 1. The 48-Hour Lethal Concentrations of Three Heavy Metals for Rainbow Trout (Salmo gairdneri). (Similar Relationships Exist for Other Species of Fish.) (7,8)

Table 6

Fish Survival and Stream Quality Data[a/]
Lead, South Dakota - January 11-15, 1975

Parameter	Spearfish Diversion (Englewood)	Hearst Ditch Whitewood Ck. Diversion	Whitewood Ck. Upstream of Gold Run	Whitewood Ck. Downstream of Gold Run	Grizzly Ck. Near Whitewood Ck.	Strawberry Ck. Tributary to Grizzly Ck.
Temperature (°C)	3.0 (1.0-5.0)	0.1 (0.0-1.0)	0.2 (0.0-1.0)	5.0 (1.0-8.0)	0.4 (0.0-2.0)	0.6 (0.0-2.0)
pH (Units)	7.6 (7.2-7.9)	7.6 (7.0-7.8)	7.2 (6.3-7.7)	8.6 (8.3-8.9)	6.9 (6.4-7.4)	7.3 (6.9-7.6)
DO (mg/l)	11.0 (9.5-11.9)	11.5 (11.0-11.9)	11.7 (10.7-12.2)	>10[b/]	11.1 (10.2-12.2)	11.3 (10.4-11.9)
% Survival						
at 24 hours	100	100	100	0[c/]	100	100
at 48 hours	100	100	100		100	100
at 72 hours	100	100	100		100	100
at 96 hours	100	100	100		100	100
at 120 hours	100	100	100		100	100

a/ Avg. values.
b/ DO probe and analyzer used.
c/ All fish died within 15 minutes after exposure.

upstream of Gold Run. It is, therefore, evident that Whitewood Creek downstream from Gold Run can support a coldwater fishery if the pollutants presently discharged into Gold Run were reduced to acceptable levels.

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APPENDIX

INVESTIGATION METHODS

AND

EPA REGIONAL REQUEST FOR

BIOASSAY STUDY

APPENDIX
INVESTIGATION METHODS

FISH SURVIVAL STUDIES

Young-of-the-year rainbow trout used in fish survival studies averaged 51 mm (38-64 mm) [2.0 in; 1.5-2.5 in] in total length and 1.5 g (1.1-1.7 g) [0.053 oz; 0.039-0.060 oz] in weight. These trout were obtained from the McNenny National Fish Hatchery, Spearfish, S. Dak. The fish were exposed *in situ* at all sites except at the Spearfish Diversion-Englewood, where water was pumped through a stainless steel tank in which fish were exposed. The exposure period at all sites was five days.

Temperature, pH, and dissolved oxygen were recorded daily at all sites. In addition, hardness, alkalinity, iron, arsenic, cadmium, chromium, copper, mercury, nickel, silver, zinc, lead (total and dissolved) and total cyanide were analyzed from Whitewood Creek samples collected upstream of Gold Run.

BIOASSAY METHODS

All 96-hour bioassays were done according to standarized methods (10) using a continuous flow proportional diluter providing a series of six dilutions of effluent and a 100 percent dilution water control.

Dilution water (receiving water) for all bioassays was obtained from Whitewood Creek 0.5 km (0.3 mi) upstream from the Gold Run discharge. This creek is the receiving water of the Homestake Mining Company effluent and the proposed Lead-Deadwood Sanitary District No. 1 discharge. The chemical quality of this water is shown in text Tables 2 thru 5. "Make-up" water was obtained from the Spearfish diversion, which is the process water for the Homestake Mining Company.

Test waters for Homestake Mining Company bioassays were obtained from the "slime plant" sluice inside the plant and the "sand plant" sluice at the head of the sand dam. These discharges were "grab sampled" daily during times of plant operation. Both samples were settled for approximately two hours, then siphoned through glass wool to remove particulate matter. Only the supernatant was used in the bioassays.

Test water for the simulated bioassays was prepared fresh daily from stock chemical concentrates prepared with the reagent grade chemicals listed as follows. ammonium nitrate (NH_4NO_3); calcium hypochlorite [$Ca(ClO)_2 \cdot 2\ H_2O$]; ferrous chloride ($FeCl_2 \cdot 4\ H_2O$); sodium cyanide (NaCN); cupric nitrate [$Cu(NO_3)_2$]; sodium arsenate ($NaAsO_2$); cadmium nitrate [$Cd(NO_3)_2 \cdot 4\ H_2O$]; lead nitrate [$Pb(NO_3)_2$]; mercurous nitrate ($HgNO_3 \cdot H_2O$); nickel nitrate [$Ni(NO_3)_2 \cdot 6\ H_2O$]; silver nitrate ($AgNO_3$); and zinc acetate [$Zn(C_2H_3O_2)_2 \cdot 2\ H_2O$]. Concentrations were calculated so that the diluter system delivered 4x, 3x, 2x, x, .05x, .025x, where x represents those concentration limits defined by the 1977 NPDES permits (text Table 1).

The test organism used in all bioassays was young-of-the-year rainbow trout obtained from the McNenny National Fish Hatchery, Spearfish, S. Dak. These fish averaged 51 mm (2.0 in) in total length and 1.5 g (0.053 oz) in weight.

All test chambers were of glass construction having an 8 liter capcity. All concentrations were done in duplicate by exposing ten fish in each of the fourteen chambers. The minimum volumetric turnover for any chamber was seven times in twenty-four hours.

Test water was monitored daily for pH, temperature, dissolved oxygen, specific conductance, total alkalinity and total hardness. Water for the simulated waste of Lead-Deadwood Sanitary District No. 1 was also tested for free chlorine and total ammonia ($NH_4^+ + NH_3$). One test chamber in each series was continuously monitored for temperature fluctuation with a recording thermocouple.

All continuous flow bioassays were 96 hours long. Mortalities were recorded at 24 hour intervals. EC50 values were estimated using a straight line graphical interpolation method (10).

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION VIII
1860 LINCOLN STREET
DENVER, COLORADO 80203

November 21, 1974

Ref: 8E

MEMORANDUM

TO: Thomas P. Gallagher, Director
National Field Investigations Center-Denver

FROM: Regional Administrator

SUBJECT: Bioassay on Homestake Mining Lease

I request your services for performing a bioassay on Homestake Mining Company, Lead, South Dakota.

Since it is required in South Dakota's Water Quality Standards that bioassay be used to determine the allowable discharge of unspecific toxic materials, this analysis is necessary. It would be appreciated that the analysis be done as soon as possible, however, considering the time element, at least by the end of January.

If further information involving the exact analysis is required, please contact Rich Andrews, the individual who is responsible for this permit. He can be reached at 837-4901.

We appreciate your help in this matter.

John A. Green

cc: Keith Schwab
Rich Andrews
Charles Murray